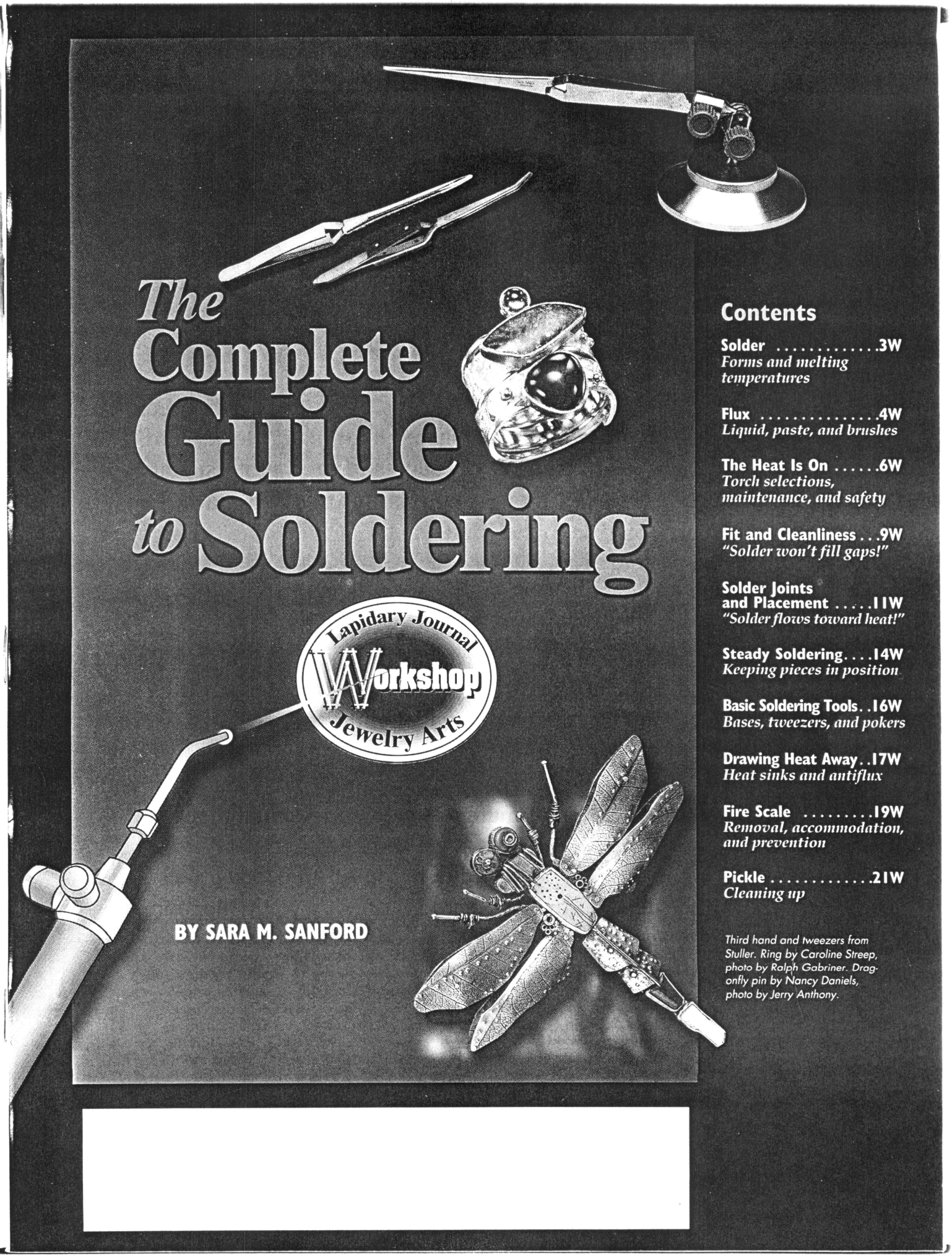

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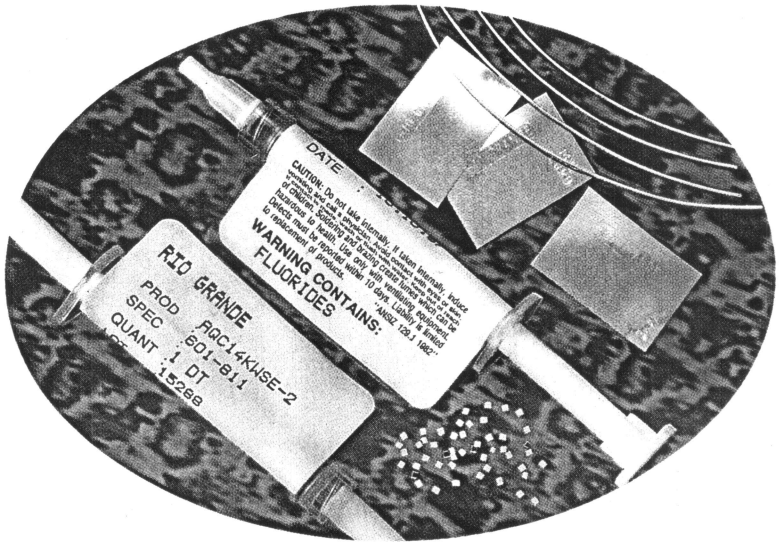
Third hand and tweezers from Stuller. Ring by Caroline Streep, photo by Ralph Gabriner. Dragonfly pin by Nancy Daniels, photo by Jerry Anthony.

Solder



Soldering is one of the most basic techniques in metalworking, but also one of the hardest to master. For a very good reason, we are taught in early childhood to fear fire, and the possibility of melting a piece that has a lot of work (and expensive materials) in it is always present. However, as with any process that has a certain mystique about it, understanding how and why soldering works will make us much more comfortable with it. Especially, knowing *why* the process works will let us do some intelligent troubleshooting, rather than simply guessing when a problem arises.

There are five basic areas that make up the soldering process: solder, flux, heat, fit, and cleanliness. If the optimum conditions are maintained in each of these five areas, the soldering process will go smoothly. It is when we begin to "fudge," or get sloppy, that things go wrong. Knowing why something happens will let us solve the problem quickly. Even the pros sometimes have to go back to basics!

Soldering is the process of joining two or more pieces of metal by using a metal alloy whose melting temperature is lower than the metals being joined. *Hard* soldering is also called low temperature brazing. *Soft* soldering uses very low melting temperature solder alloys, usually of tin and lead, and is not commonly used in fine jewelry.

Solder is a nonferrous (without iron) metal alloy, the major percentage of which is usually the same as the metal being joined: gold, silver, copper or brass. *Gold* solder is available in different colors to match various alloys. Because brass and copper solder, both also known as *brazing rod*, has a high melting temperature and is brittle, *silver* solder is usually used on these metals as well as on silver. All of the nonferrous metals (gold, silver, copper, brass, or bronze) that have a relatively high melting temperature can be soldered with either gold or silver solder. Both gold and silver solders are available in different melting temperatures, and are manufactured in several forms.

Forms of solder include *sheet, wire, pallions (clippings or chips), and paste.* Which form of solder to use is a matter of training and personal choice. I prefer to use sheet, cut into small pallions, because wire solder, being round, will sometimes roll away from the force of the flame; sheet stays where you put it (usually). Paste solder, a mix of tiny bits of solder mixed

Continued on page 5W

TOP: Solder comes in many forms: wire, sheet, chips (pallions), and paste. Gold solder assortment images courtesy Rio Grande.

Flux

Used to help solder flow, flux comes in both liquid (left) and paste (right) forms. It is also recommended for its usefulness in limiting fire scale (center). Images courtesy Rio Grande.

You must have flux in order to join metal together in the basic metalsmithing process of soldering. Flux is a liquid or paste compound that is applied to the metals being soldered. By keeping the metals clean of oxides, flux helps solder flow (see "Solder," Technically Speaking, December, 1998). Flux also acts as a temperature indicator: by observing the changes in the flux as heat is applied, you can gauge when the solder is about to flow.

Liquid flux, sold by trade names such as Battern's© Self-Pickling Flux or Solder Fast™ High Temperature Flux, can be used with gold, silver, copper, brass, or bronze. Liquid flux is usually used on gold and on other metals for delicate soldering operations such as joining a bezel.

The main advantages of liquid flux are one, that it is reasonably transparent and therefore will not obscure the solder seam during heating, letting you watch the soldering process closely; and two, it will flow more easily into solder joints than will paste flux. Liquid flux also has a wider temperature range (1100°F to 1700°F).

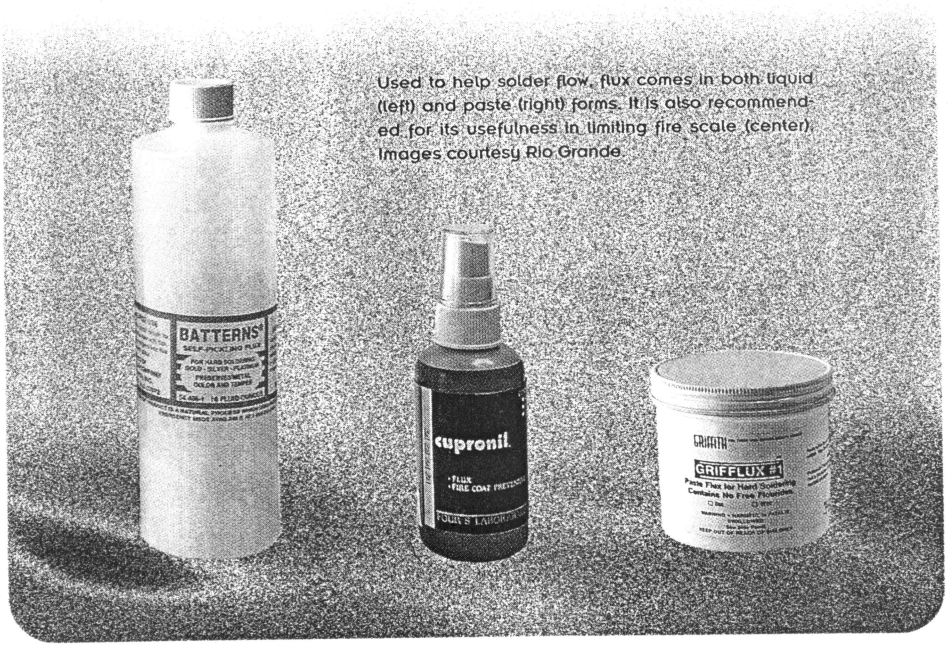
Any flux forms a glaze on metal that acts as a barrier to air, and this prevents the formation of oxides that produce the darkening called fire scale. The wider the coverage of the flux, the greater the protection from fire scale. With relatively little coverage, however, liquid flux offers only minimal protection from fire scale.

Paste flux, sold by trade names such as Handy Flux© or Grifflux #1©, is a white, water-based compound containing borax and boric acid. Like liquid flux, paste flux can be used on gold, silver, copper, brass, and bronze. It can also be used on steel, although there are fluxes manufactured specifically for use when soldering steel with silver solder. Paste flux is commonly used on silver and base metals, especially when working on larger pieces such as hollowware, as it has much better covering capability than liquid flux. As a result, paste flux can also help a good deal in limiting fire scale.

Paste flux has its disadvantages as well. It is an opaque white that obscures the joint from view until just before the soldering temperature is reached. It also has a narrower temperature range (1100°F to 1500°F) than liquid flux.

The old traditional flux was a **borax cone**

Flux



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ground with water on a piece of slate to make a paste. Paste flux can also be made from borax (but do not use Boraxo!) and boric acid in varying proportions, sometimes with other ingredients added. Most jewelry and metalsmithing how-to books contain formulas that you can consult if you want to experiment with making your own flux.

Which flux to use when? My suggestions:

- Liquid: use when soldering bezel ends, heads, findings, or any seams where the metal contact is minimal.
- Paste: use when the metal surfaces to be soldered are large, as in sweat soldering, or when the object is large, such as a belt buckle.

After selecting the type of flux and applying it, you may discover that you have used too much. As they become hot, both liquid and paste flux will bubble up and may displace solder pallions, and any excess flux will only make this more likely. How much is too much? Only experience can really teach you that, but if, for instance, your liquid flux forms huge puddles, you've probably used too much.

Excess liquid flux can be wicked away with a dry brush or a piece of tissue before heating to help prevent the solder from being displaced. Another useful product for this is the "tortillian," a tightly rolled, pointed paper stick used to smooth and blend pastel and charcoal drawings, which is sold in artist's supply stores. A fairly dry brush is necessary to remove excess paste flux.

To minimize solder displacement during heating, heat the flux gently until the water in it evaporates and the solder pallions settle down. Replace any solder pieces that have moved.

When you begin to apply heat, paste flux will remain an opaque white, while liquid flux will go from transparent to semi-transparent and grainy. As the melting temperature of the solder is approached, both fluxes will turn transparent. This is the signal to zero in on the solder seam, concentrating the heat on the area to which you want the solder to flow.

Regardless of which flux you use, one of the most important factors is to keep the flux clean. Pour small quantities of either flux into a small glass container with a wide mouth (plastic should not be used on the soldering bench), such as a sample jar used for jams or mustards. It should have a tightly fitting lid, as both fluxes are water based and will evaporate if left uncovered.

Paste flux will dry out and harden if not used regularly. Add water periodically to prevent this. If the paste flux does dry out, it can be reconstituted by adding a small amount of water and heating the uncovered jar in a microwave oven, stirring frequently; or by placing the uncovered jar in a pan of boiling water (at a level that will not flow into the jar) on top of the stove, heating and stirring until it reliquefies, adding small amounts of water as necessary.

A last word on flux brushes. Since the bristles do tend to burn down quickly, many jewelers use very cheap brushes. I think this is a mistake. You need not use a sable hair brush, but I recommend using at least a camel hair brush for fluxing and for placing small pallions of solder. The coarser hairs of a cheap brush will not pick up solder pallions as easily, nor will it dispense the flux as smoothly along the seam. Using quality tools always makes the job easier. ◆

Solder . . .
(continued from page 3W)

with a paste flux, is used primarily by mass producers in machine soldering and is the most expensive form of solder. Knowing how much paste solder to use requires a bit of experimenting.

Melting temperatures of solder are determined by the zinc content: the higher the zinc content, the lower the melting temperature. Zinc is what turns the lower melting temperature silver solders a yellowish-gray; to avoid conspicuous solder lines, use the highest temperature solder feasible. Pits in the solder seam are caused when the solder is overheated and the zinc burns out. Again, using a higher temperature solder (and controlling the heat) will help to prevent pitting.

The most common divisions of melting temperatures in *silver* solder are:

IT: the highest melting temperature, used on fine silver when enameling;

Hard: used for bezels and as a first step when doing multiple soldering;

Medium: used mostly when only one or two steps will be done;

Easy: used as a final solder or when soldering on findings; and

Extra Easy: used primarily for repairs (distinctly yellow in color).

Gold solders come in Hard, Medium, Easy, and Extra Easy as well as different karats and colors. One manufacturer has recently come out with a Medium Hard silver solder, with a melting temperature between that of hard and medium solder.

Because sheet and wire solder are indistinguishable from regular sheet and wire metal, these solders should be marked as soon as they are purchased. Sheet solder can be scribed with 1, 2, 3, or H, M, E (for hard, medium, easy); wire solder can be hammered or even have knots tied in one end. In order to distinguish between the different melting temperatures, some schools like to use a different form for each: wire for hard, sheet for medium, and flattened wire for easy.

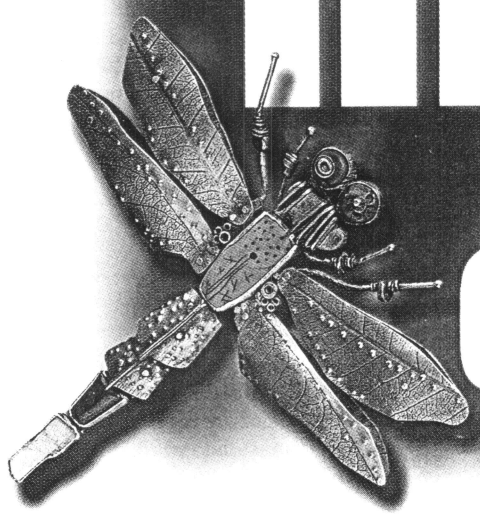
Why use different melting temperature solders? When fabricating a complicated piece, using different melting temperature solders will help prevent the previously soldered joints from remelting, and either shifting or coming unsoldered. (Additional techniques to prevent this will be discussed separately.)

There is no industry standard for exact melting temperatures, and each solder manufacturer has its own specifications. Therefore, buying all your solder from one source will help keep the different melting temperature solders straight, although a combination of solders from different manufacturers may give you more versatility.

You will often see two temperatures listed: a melting point and a flowing temperature, which is higher. The *melting temperature* is when the solder starts to melt, and the *flow point* occurs when the solder is completely molten. The difference between these two temperatures, or *spread*, can be from 25°F to more than 100°F. It's important to know the spread, since it will affect where and for how long you apply the heat. Experimenting with solder from different sources will give you the opportunity to find just the right combination that suits you. ◆

If you can't stand the heat, stay out of the studio . . . but if you're looking for heat, what's the best source?

the HEAT is on



No one knows just when prehistoric man first discovered that by blowing air across an open flame the flame not only became much hotter but could also be aimed at a particular spot. What *is* certain is that soldering is one of the most fundamental aspects of metalsmithing, joining two pieces of metal together, and essential to soldering is a reliable source of heat. And what would that be? The earliest jewelry makers used a blowpipe; artisans these days usually use a torch.

TOP: Ring of reticulated 18K and 22K gold, Boulder opal, tsavorite, and red tourmaline by Caroline Streep, photo by Ralph Gabriner

ABOVE: Silver dragonfly pin with sterling silver, coral, fossil ivory, and sugilite by Nancy Daniels, photo by Jerry Anthony Photography

For either gold or silver soldering, this means a temperature range of 1,200°F to 1,800°F. But producing high temperatures is not the only consideration, especially for silver soldering. Since silver conducts heat rapidly, the heat source must be able to maintain the soldering temperature over the entire piece — the same is true when soldering copper and, to a lesser degree, brass and bronze. Because gold doesn't conduct heat nearly as quickly, it can be "spot soldered," or heated only in the area where the solder seam is being joined.

There are many different torches available, with several options for fuel. Each has its advantages and disadvantages, and since torch units can be expensive, the type of work you do will help to determine which torch unit you buy. The following information covers the major types of torches available to both professional and hobbyist. All are sold through the usual jewelry tool sources, and in most welding supply stores. (What we in the jewelry field call "soldering," welders call "brazing"; to them, "soldering" is using the very low temperature/tin solders.)

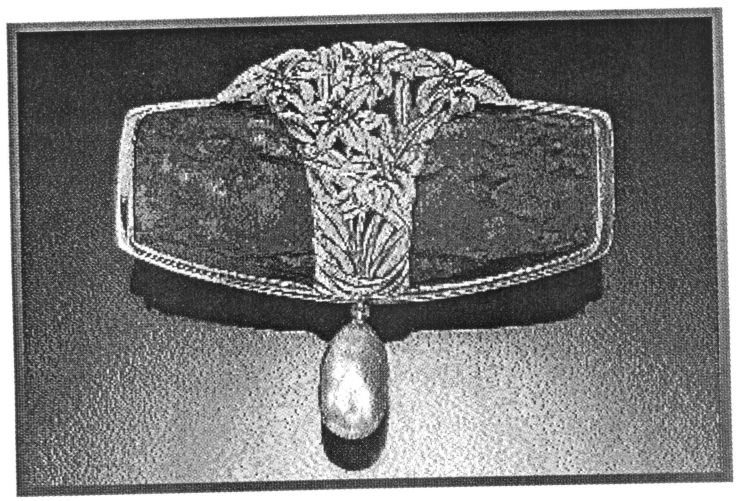
A preliminary word on safety: *any* torch unit can be dangerous, so read and understand the instructions thoroughly before you use it. If necessary, have a qualified instructor show you how to use the torch.

The earliest torches were simply open charcoal fires, with a blowpipe, possibly a hollow reed, used to focus the heat on the seam. The modern equivalent is a brass blowpipe used with an alcohol lamp or Bunsen burner. Proponents of this method claim that it is the best way to obtain maximum control of heat for soldering, but it can be surprisingly hard to find; in a recent survey of three major jewelry tool supply catalogs, I failed to find this simple, if technologically primitive, tool.

Torches come in two basic categories: a single gas blended with air (either ambient air or compressed air), or as a two-gas mixture. Single-gas models tend to be the lower temperature units, while torches that mix gases reach much higher temperatures.

SINGLE GAS TORCHES. The simplest, and least expensive, torches are the single-gas units. Sold under such trade names as BernzOmatic™ in hardware stores and home centers, these torches use either propane or MAPP® gas (a synthetic gas: methylacetylene propadiene) in small disposable cylinders, with a fixed torch handle. A flexible hose with torch head is available to fit these cylinders, so you don't have to hold the entire tank when soldering. MAPP® gas is a bit hotter than propane, and capable of maintaining a high temperature for a longer period of time. Either will work for small soldering jobs, but cannot produce enough heat for larger pieces; and the flame is not as adjustable as on the more expensive torches.

There are also very small butane torches, such as the Blazer Microtorch™, but these have a limited usefulness, as they do not produce a large enough flame for most silverwork. Also, the fuel capacity is very small, meaning that the fuel may run out just in the middle of the soldering operation.



A common use for torches is to solder the pin backs onto brooches, such as this one of boulder opal and pearl by Tom Herman. Photo: Ralph Gabriner.

Another single-gas torch is the acetylene torch, sold under the brands Prest-O-Lite™, Sod-R-Braze™, and other proprietary names. Using a single tank of acetylene, which is mixed with ambient air at the torch head, this is much hotter than the other single-tank torches. While it is commonly used for melting metal when casting, it can be too hot for delicate soldering. And acetylene is a very dirty gas, giving out ribbons of greasy soot if not regulated quickly when being lit.

A common gas and air combination found in many schools is natural gas and compressed air. Similar combinations are propane or MAPP® gas and compressed air. The large, bushy flame that this torch produces is not very hot — great for annealing large hollowware pieces, but not very efficient when doing small soldering work, and inadequate for casting or work requiring large, very hot flames, such as soldered lamination or mokume gane.

While any of these torches can be used for occasional or very limited work, a professional would require the versatility provided by a dual-gas torch.

DUAL GAS TORCHES. Most professional jewelers use a two-gas combination for soldering and casting, either propane, MAPP®, natural gas, or acetylene combined with oxygen. The addition of oxygen to any of these gases results in a much hotter flame, and also allows a greater range of flame sizes. Propane, MAPP®, or natural gas are all roughly equal in working characteristics when combined with oxygen; acetylene, on the other hand, is much hotter than the other gases when used with oxygen.

I have found that jewelers tend to prefer whichever torch and gas combination they were trained with. For instance, I personally prefer the versatility of oxy-propane, finding oxy-acetylene too hot, too dirty, and much too limited for the larger-scale silver work I do. I use large tips for melting metal while casting, and very small tips (down to .018") for soldering gold, all with the same torch handle. On the other hand, commercial or trade jewelers often prefer oxy-acetylene, because the tiny, very hot flame works well for the gold ring sizing, prong retipping, and chain repairs which comprise the majority of their work. Larger studios and trade shops that do a wide variety of work will usually have two or more types of torches.

There are many brands of dual-gas torches available, with tank sizes ranging from small, disposable cylinders to huge commercial tanks. All require two tanks, two regulators, twin hoses, a torch handle, and tips. Most torch manufacturers make several sizes of torch tips, from large melting or casting tips (such as "rosebud"), down to tips so small it is claimed that you could weld steel wire inside a recessed cigarette filter without burning

the paper. (This is fine if you *want* to weld wire inside a cigarette filter; they are too small to do much else!) The tips are made for different combinations of gases, and are not generally interchangeable between propane and acetylene, so be careful when ordering tips to specify which gases you will be using. Follow the manufacturer's recommended pressure setting at the gas and oxygen regulator for each tip. You will have to adjust the pressure at the regulator when you switch tips, otherwise the flame may not light, or not stay lit.

A recent technological innovation is the "water" torch, so called because it electrolytically breaks water (H_2O) down to its component parts, hydrogen and oxygen, and uses these gases as fuel. This torch has limited applications, since the flame, while hot, is very tiny, and not suitable for larger silverwork. It does function well for most small goldwork and repair jobs, though, and is used in production assembly.

For situations that prohibit using an open-flame torch, many rely on an electric soldering machine. Utilizing the heat generated by high-voltage electricity, it can be used to size rings, retip prongs, and solder jump rings. But as with other very small sources of heat, it cannot replace a regular torch for working with larger pieces, or with silver. Some trade shops use this electric machine to "tack" multiple parts in place, then switch to a regular open-flame torch to finish the job.

Another machine popular with production jewelers is the Sparkie™ fusion welder. It does not solder, instead using a charge of electricity to create a very hot spot, which fuses the two metals being joined. Its primary function is to attach findings such as ear posts, or to join metals which cannot be soldered, like tintanium or niobium.

With all these options, how do you select a torch? By considering how you work and what kind of things you do, the choice can be narrowed down. The hobbyist can get by with the least expensive, single-gas torches, but the professional will find this too inefficient. The professional who works only with gold or platinum may opt for oxy-acetylene, perhaps with the water torch or electric soldering machine as auxiliary torches if doing primarily repairs. Probably the most versatile unit is the propane and oxygen torch (or oxygen with natural gas if possible). Working with the small disposable cylinders for propane, MAPP®, and oxygen is less expensive initially, but the gas tanks need replacing frequently, and are not environmentally sound. Even a serious amateur may find that purchasing a larger tank system will be more cost effective in the long run, and will certainly be more efficient to use.

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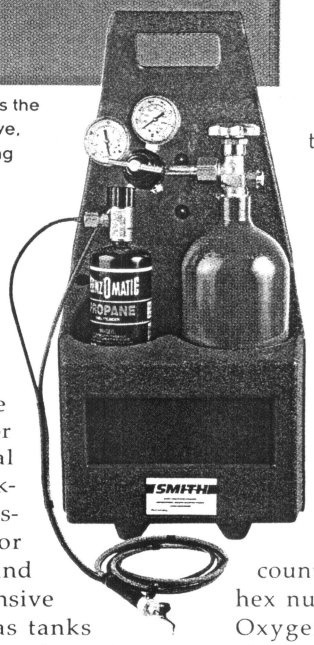


Single-gas torches, such as the pencil-torch kit shown above, are good for small soldering jobs. Double-gas torches, such as the propane torch system shown at right, are more expensive, but more versatile. Photos courtesy Rio Grande.

Regardless of which type of torch works best for you, I cannot stress safety enough. None of these torches are playthings, and all should be kept well out of the reach of children, pets, and uninformed adults. All tanks should be secured in a cart, or chained to the wall. If an oxygen tank falls over and the regulator breaks, the tank could take off like a rocket. In many areas, propane is not allowed inside a building, so check your local fire regulations. For this reason, some people choose to have natural gas piped in to use for a torch.

Natural gas is lighter than air and will rise, while propane is heavier than air and can pool inside a room. If that happens, just turning on a light switch can create a spark and cause an explosion. However, even natural gas isn't necessarily safe. A student's husband, a fire captain, once told me that he could always tell whether a fire had been caused by natural gas or propane: if the top of the room was blackened, it was natural gas, since natural gas rises; if the flash point was on the bottom of the room, then it was propane. The point of the story being: it doesn't matter which gas you use, both are potentially dangerous. So again, *think safety first!*

MAINTENANCE AND SAFETY. Now that I've scared you, let's talk about what you can do to make your work area as safe as possible. Regular maintenance is your best safety precaution. Replacing the hoses and having your regulators checked each year is a simple and effective way to help prevent accidents. Another simple safety precaution is the use of flashback check valves, which prevent the flame from being sucked back into the hose and possibly reaching the tanks.

Industry standards go a long way towards making professional torch equipment "idiot-proof." All gas connections are threaded counterclockwise, have a grooved hex nut, and all gas hoses are red. Oxygen connections are threaded clockwise, have a smooth hex nut, and all oxygen hoses are green. Theoretically, this means that it is impossible to mismatch the connections, but following instructions and paying attention while you work is always the best policy.

Continued on page 10W

Fit and Cleanliness

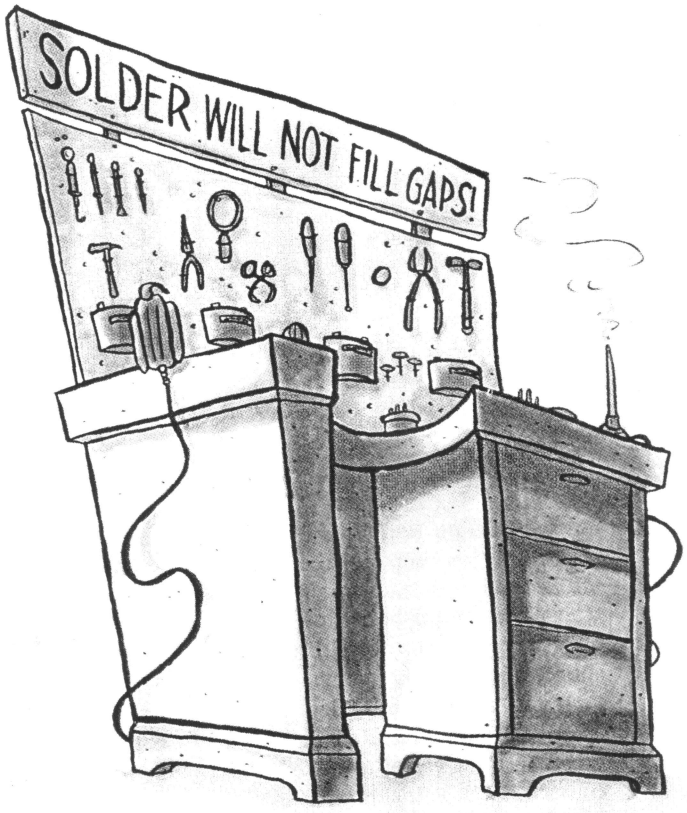


Illustration by Steve Spatucci

Underlined in red and written in capital letters, the phrase "Solder will not fill gaps!" ought to be hung above every soldering bench. It is one of the most important but probably the most disregarded maxim in soldering, with predictable results.

Solder flows by capillary action. The narrower the joint, the more efficiently the solder will flow. And what gives you a narrower joint? A closer fit. This means that if you spend a little more time filing, sanding, and fitting, you will need to take less time cleaning up after soldering or redoing the solder joint. Here's one more saying to hang up there above your bench: "If you don't have time to do it right, where will you find time to do it over?"

In the past, my students have told me that my favorite phrase is: "Just a little bit more." This applies to everything about making jewelry, but especially to making sure the fit of a solder seam is as close as is humanly possible. Unfortunately, the only way to achieve a close fit is through diligent work, which can be made easier by using the proper tools and supplies to accomplish the job at hand. Having the correct shape of file to get that notch just right, for example, or the appropriate grit of abrasive paper will make the task much easier, but it is still up to you to do it right — and the savings in time, effort, and frustration are well worth it.

The secret to a good solder joint lies in the preparation: being sure the **fit** is as close as possible is the first step. The second step

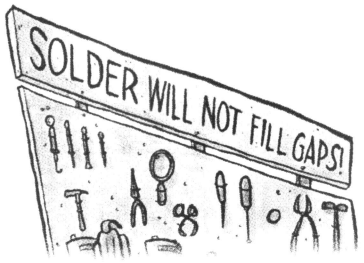
Fit and Cleanliness . . .

should be **cleanliness**. Solder will not flow over a dirty area, so thoroughly cleaning the parts to be joined is essential. And both the flux and the solder must also be clean, or the joint may be contaminated.

Flux does not like to stick to a shiny surface, so if you are joining two polished parts, use abrasive paper or an abrasive wheel on the flexible shaft to slightly roughen the areas to be joined. Then the flux will stay in place without balling up. This is also a way to be sure that you have a clean surface, free of grease or oxides.

One of the best habits to get into is washing your hands each time you clean the metal parts you are working with. Boraxo™ or other slightly abrasive hand soap is the best I've found for removing polishing compounds and other grease from your hands. For those with sensitive skin, a less abrasive cleaner might be used, although I've never met a true "hands-on" jeweler with a perfect manicure!

Before it is cut, clean the sheet or wire solder with fine steel wool or a Scotch Brite™ pad. I keep precut pieces of sheet solder in small hinged plastic boxes on one side of my soldering bench, separated by kind of metal and melting temperature. For



medium silver solder, which I use the most of, I even have different boxes for various sizes of pallions: tiny, small, medium, and large. This saves me from hunting through a box of mixed sizes when I need just one.

Because I usually dip my moist flux brush into the solder, the box and pallions become sticky over time. To remedy this, I clean them in my ultrasonic cleaner using a small, stainless steel, mesh container that is designed for cleaning tiny watch parts. Then I thoroughly clean the plastic box as well. A stainless steel, mesh tea strainer spoon will work also, but the mesh is not as fine as the watch part container, and tiny pieces of solder may fall out.

Let me repeat: *If the optimum conditions are maintained in each of these five areas, the soldering process will go smoothly.* It is when we begin to "fudge," or get sloppy, that things go wrong. But knowing why something happens will let us solve the problem quickly. Even the pros sometimes have to go back to basics! ◆

The Heat is On . . .
(continued from page 8W)

Use a wrench to tighten all connections when replacing the regulator after changing tanks, or attaching hoses and the torch handle. And, of course, *never use oil* on any torch or regulator parts. When combined with oxygen, oil is explosive — that's what fuels rockets. You can paint a solution of soapy water on the connections to check for any leaks, which will blow bubbles. But be sure to use a soap that doesn't have any oil in it, such as Ivory™ liquid; and to dry the connections thoroughly afterward.

If you purchase a twin-tank torch system, you will need to refill the tanks at intervals. A welding supply can take care of the oxygen and acetylene, and many gas stations will be able to refill a propane tank. Note that you will use far more oxygen than propane or acetylene, and will need to replace that tank more often. When you take an oxygen tank in for a refill, some suppliers will offer you a replacement tank, rather than have to refill the tank you brought in. This is fine, but be sure the tank you accept is in at least as good condition as the one you brought in, not corroded or rusted. Or if you don't mind the wait, have your own tank refilled. Most welding suppliers offer a delivery service, but if you choose to transport your own tank, be aware of the Federal regulations regarding the transportation of hazardous materials. Again, your local welding supply source can give you information.

If you use a larger tank of propane as one of your fuels, it is a good idea when refilling it *not* to have it filled completely. For instance, I use a 7½ gallon tank, but only buy five gallons of propane at a time. This way, when the gas expands during warm weather, a full tank will not overflow, creating a pool of propane on my studio floor.

When replacing tanks, "crack" the valve slightly by quickly opening and shutting the tank valve. This will blow out any dust which might have accumulated inside the valve, and prevent it from damaging the diaphragm in the regulator.

As you close down the studio for the day, be sure to turn off your torch completely. This means turning off the tank valves and fully releasing the pressure in both regulators. Some welders get into the bad habit of turning the tanks off, but leaving the regulators set to the preferred pressure. This is potentially dangerous; the force of high-pressure gas hitting the diaphragm can cause a blow-out.

According to government regulations, all suppliers, either for jewelry or welding, must offer an MSDS — a Material Safety Data Sheet — with each purchase. It's a good idea to collect these for all materials you use in the studio, read them, and keep them on file for future reference. Each MSDS contains vital safety information, including emergency contact telephone numbers, precautions for handling or using the material, physical properties, hazard data, and waste disposal information. If you have employees, you are required by law to keep on file an MSDS for every product you use, and make it available to all employees. This applies not only to the more obviously hazardous materials like acids or plating solutions, but even to things like soldering flux. Even though manufacturers and suppliers cannot legally assume any customer's awareness of potential hazard, and try to emphasize precaution, we are all ultimately responsible for our own safety. Common sense and a thorough knowledge of and respect for the products and processes will always be the best precaution. ◆

Solder Joints and Placement

"Solder flows toward heat!"

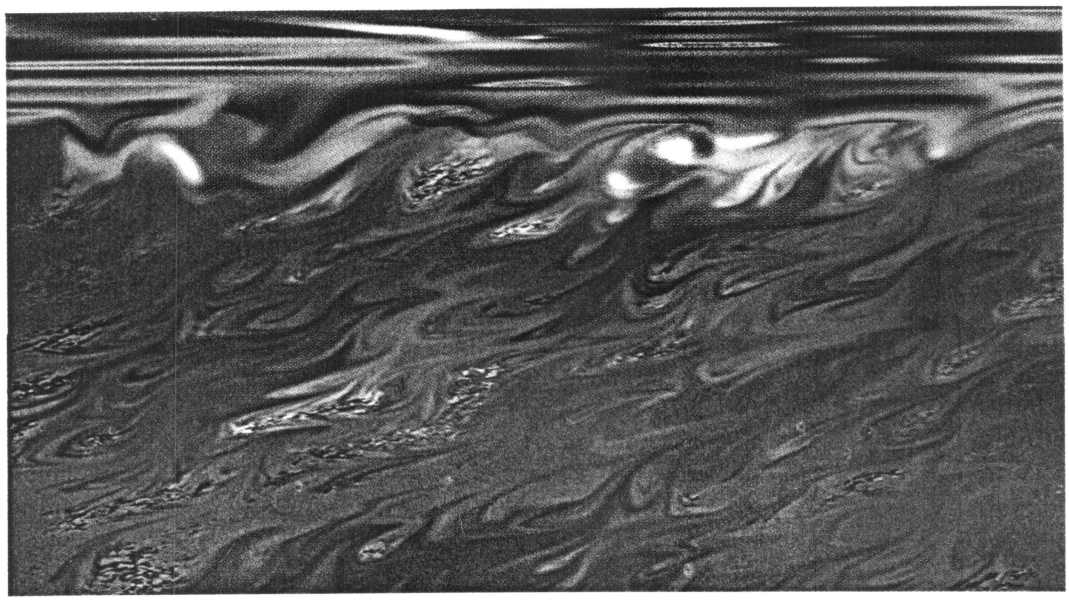


Illustration by Kevin Myers

There are three basic types of solder joints: **sweat**, which is surface to surface (joining two flat sheets of metal, one on top of the other); **strip**, or edge to surface (joining a bezel to its base); and **butt**, or edge to edge (joining two sheets abutting, or side by side, as in marriage of metals or as in two wires end to end). Each type of joint calls for a different approach to solder placement and heat control, but for all three types of joints, the main factor is the same and cannot be overemphasized:

- *Solder flows toward heat.*

This simple fact dictates where the solder is placed and how the heat is applied in any solder joint. Disregarding this principle causes more frustration and disasters than anything else except a poor fit.

FOR SWEAT SOLDERING, or joining two pieces of sheet material, one on top of the other, the easiest way is to flow the solder over the underside of the top (usually smaller) piece, then flip this over onto the bottom (larger) piece.

After checking the fit and cleaning both surfaces, start by fluxing the underside of the top piece and the top of the bottom piece. If the areas to be joined are large, say bigger than about a half inch square, paste flux is the better flux to use. If the areas are smaller, then liquid flux can be used.

Place the solder pallions on the underside of the top piece. How much solder to use is something learned only by experience, but a good rule of thumb is to cover about 20 percent of the area with solder (when using thin gauge sheet solder). Too much solder will flow out of the joint and flood the bottom piece, while too little solder will result in a bad joint. Solder has a tendency to pull away from the edge of the metal, so place solder as close to the edge as possible. Sweat soldering will use more solder than any other type of joint, so larger pieces of solder can be used.

If the top piece of metal extends beyond the edge of the bottom piece, mark the underside of the top with a scribe where the edge of the bottom piece will be. To prevent the solder from flowing over the extension where you don't need it, you can coat the area with a thin paste of yellow ochre (yellow ochre will be included in an upcoming discussion on antifluxes). Leave at least a one-millimeter border between the yellow ochre and the fluxed area so they won't mix and contaminate the flux.

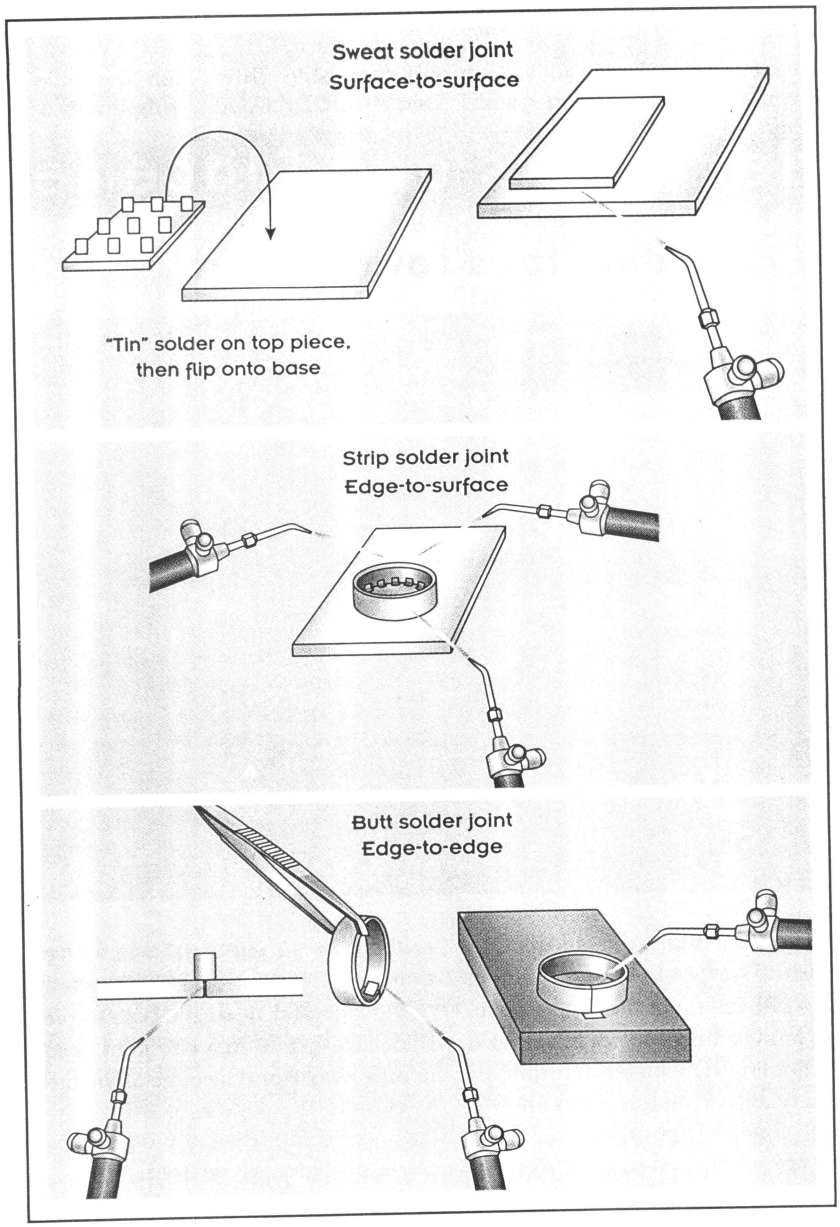
Place the smaller piece of metal, with flux and solder side up, on a mesh screen on top of a tripod. This allows you to apply the heat from beneath and take advantage of that incontrovertible fact that *solder flows toward heat*. Use a titanium or steel poker to spread the solder once it becomes liquid, "tinning" the surface with solder.

If the flux doesn't burn off and leave black spots (oxidized bare metal), you can simply reflux the top piece after it cools slightly, flip it over, and position it on the bottom piece. If the flux does burn

off and there are black spots, pickle the piece, lightly sand and thoroughly clean it, and reflow the solder, adding flux and more solder if necessary.

Flux the top piece, then position it on the bottom piece. Place both pieces on the mesh screen on the tripod, and again, heat from beneath; the bottom piece is usually the larger one and will take longer to heat. Using the flux as a temperature indicator, continue heating from underneath until the flux turns glassy, then bring the torch flame up on top and heat until the solder flows. This can be difficult to see: look for a liquid silver line where the two pieces are joined.

Slight pressure can be applied with a poker to the top piece as the solder begins to flow, but if you try this, be careful not to apply too much pressure, as metal at soldering temperatures is easily marred or distorted. Remove the torch, allow the piece to cool slightly, and then place in pickle.



STRIP SOLDERING. The typical strip solder joint is used in soldering a bezel, a peg for a pearl or bead, or wire decorations onto a base. After making the fit as close as possible and thoroughly cleaning all the parts, flux the smaller part to be soldered and position it on the base, wiggling the smaller piece around a bit to flux the base. (Because the joint is usually small, liquid flux is my choice for most strip solder joints.)

When choosing the size of solder pallions and where to place them in a strip solder joint, there are several things to consider. In general, I prefer to use smaller pallions and more of them, rather than larger and fewer pieces. Solder flows by capillary action, and smaller pieces placed closer together don't have to flow as far. Because solder leaves tracks wherever it flows, using smaller pieces also cuts down on clean-up afterward, even if it means spending more time placing the solder beforehand.

Where to place the pallions depends on the design of the piece and how the heat will be applied. Solder should be placed where it will be either least conspicuous or most easily cleaned up. For soldering a bezel, for instance, this usually means placing the pallions on the inside of the bezel, where the stone will hide any solder tracks. But for soldering a raised frame to a base, it might mean placing the solder on the outside, on a small "shelf" left for this purpose when cutting the base. Afterward, the shelf and the solder tracks can simply be filed away.

The main consideration, however, is how the heat will be applied. Remember that *solder flows toward heat* (have I mentioned this before?). Place the solder on the side of the joint *opposite* where you intend to apply the heat, and the heat will draw the solder through the joint.

Commonly, in strip soldering, the pieces to be joined are of very different sizes and so will heat unevenly. The larger pieces will need more and longer heating to bring them up to soldering temperature, and the smaller pieces can easily be overheated and melted. The solder pallions will be the smallest pieces of all, so: **never heat solder directly**, but instead, heat the areas where you want the solder to flow because — that's right — *solder flows toward heat.*

For a typical **bezel**, I'll use solder pallions of about 1mm square, placed about 3mm apart, around the inside of the bezel. The heat is directed first on the base, from *underneath if it is* placed on a mesh screen on a tripod. Only when the flux turns glassy, indicating that the melting temperature of the solder is being approached, will I bring the torch flame up on top

and then circle the outside of the bezel until the solder flows and the heat draws it out through the seam.

To solder on a **wire peg** for a pearl or bead, I usually prefer to drill a hole in the base for the wire, so it will stand on its own and won't need to be held in place. This also increases the contact between the wire and the base, strengthening the joint.

A small pallion of solder where the wire joins the base is all that is needed; again, heat the base, from beneath if possible, and direct the torch flame at the joint only when the flux has indicated the correct temperature. If drilling a hole for the wire is not feasible, I usually premelt a small bit of solder on the end of the wire, which is held in crosslock tweezers, and then heat the base to the melting temperature of the solder before placing the wire down on the base. (Technically, this last is a sweat solder operation.)

BUTT SOLDERING. A butt joint is produced by soldering the ends of a bezel together, joining sheet metal edge to edge (for "marriage of metals") or joining the ends of a wire to make a frame or ring. Again, the fit is critical. Keep the edges of a bezel perfectly level, not rounding the corners, or there will be a gap. If possible when using larger gauges of metal, increase the surface area of the joint by beveling each edge to create a diagonal cross section. This is more difficult and time consuming but will result in a stronger joint.

The best arrangement for butt soldering is to place the solder on the backside of the seam, place the pieces on a mesh screen on a tripod, and then heat from underneath. However, if you want to join multiple pieces or if they are not level, you may need to place them on a soldering pad or coil to hold the parts in place while soldering.

In this case, control of the heat becomes critical, because you will be heating with the solder side up, and since *solder flows toward heat*, the solder will have a tendency to spread out rather than flow downward through the joint. You may need to reheat the piece from the front to draw the solder through the joints; if you do, make sure that all parts are held securely in place so they won't shift, and don't forget to reflux as well.

To **solder a bezel closed**, I usually hold it in a pair of crosslock tweezers on the side opposite the joint, place the solder on the inside just across the joint, and turn my torch flame vertically so the upward-pointing flame heats the entire bezel evenly. Using your smallest pair of pointed crosslock tweezers, just barely hold the bezel in the tips. Especially on small bezels, using a broad-tipped tweezer may cause the bezel to spring open when heated, separating the solder joint. The same technique for bezels applies to soldering **frames or rings**: hold in crosslock tweezers in a vertical flame with the solder on the inside of the joint.

For **soldering jump rings closed**, I place the solder pallion on a soldering pad, then (after fluxing both ring and solder) place the jump ring joint on top of the solder. This prevents the solder from shifting during the heating process, and since *solder flows toward heat*, heating from above will draw the solder upward through the joint. When making a chain, solder half the links closed first, on a flat surface, then join these links with the remaining jump rings.

Whenever a solder job is not going well, stop and rethink the process. Do I have the right solder for this job? Have I used the appropriate kind of flux? Do I have the right kind of heat source, and am I applying the heat in the best manner (i.e., am I remembering that *solder flows toward heat*)? Is the fit as close as possible, and are all the parts, including the solder and flux, clean?

Usually, upon a little reflection, the answer becomes evident. ◆

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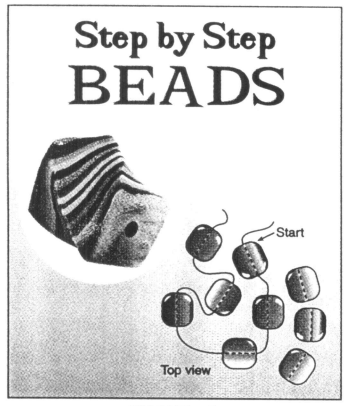

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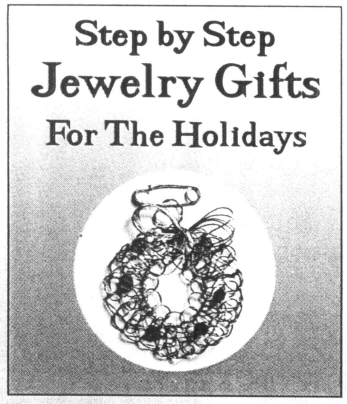

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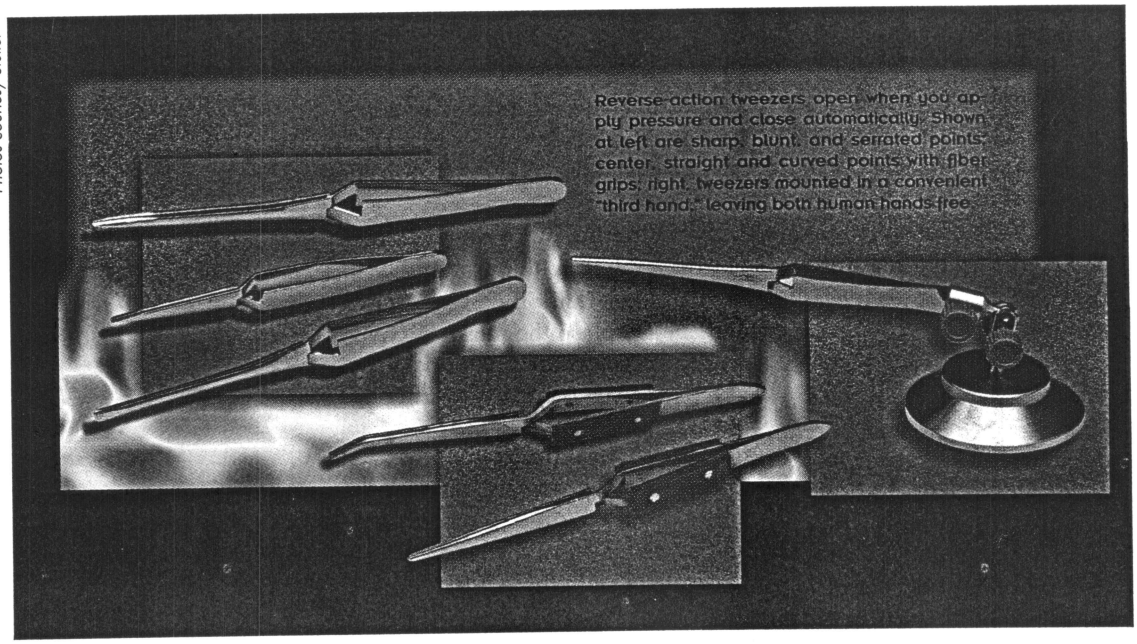
Steady Soldering

How to keep your pieces in position during soldering

Photos courtesy Stuller



Reverse-action tweezers open when you apply pressure and close automatically. Shown at left are sharp, blunt, and serrated points; center, straight and curved points with fiber grips; right, tweezers mounted in a convenient "third hand," leaving both human hands free.

One of the essentials of soldering is heating the solder until it flows. Another essential is the precise placement of the pieces of metal you are trying to solder together so that they become joined the way you want them to be joined. But because one or more of your pieces may virtually be floating on liquid solder once it has become molten enough to flow, the piece or pieces may shift position just as you are joining them. There are several things you can do to minimize this tendency and keep your joins precisely placed. (For details on where to place solder and how to heat it, see "Solder Joints and Placements," December, 1999.)

As it does with everything else, gravity plays a role in soldering, so keeping all pieces as level as possible will help prevent them from floating "downstream." Even if the two (or more) pieces being joined are not level to begin with for design purposes and the fit is especially critical, there are several ways to keep them from shifting.

One way is to raise **"stitches"** of metal on the base piece with a graver. These little bumps or prongs will hold the other piece or pieces in place while heating. To create stitches, first scribe a line on the base piece, tracing the outline of the top piece on the spot where you want it to be soldered. This will work on either a flat or a gently curved surface. Again, gravity will take over if the curve is too steep or the top part too heavy.

Using a pointed graver (or a knife or onglette shape), and working from the inside of the scribed line, dig the point of the graver into the metal at about a 30° angle. Just at the edge of the scribe line, push forward only slightly (less than half a millimeter), and then rock the graver upward, raising a sharp point of metal. Do this on at least three points around the scribe line, checking the fit each time. Only a very small stitch is necessary, and a small stitch will just disappear into the solder joint. With a bezel, the stitches can be placed inside rather than outside: scribe a line inside the bezel, and raise the stitches from the outside inward.

Another traditional way of holding pieces in place while soldering is to use **binding wire**. Binding wire is a soft, iron wire, which is sold in various gauges. Its primary use is in making large hollowware pieces, such as holding a spout to a teapot while soldering. Binding wire can also be used on smaller pieces but must be used with some forethought to prevent marring. Also, being a ferrous material, iron binding wire *cannot be put* into the pickle, so it must be removed completely before pickling. (There is a stainless steel binding wire available, which, while more expensive, will not contaminate pickle.)

Because solder will adhere to binding wire quite easily, if the binding wire crosses a solder seam, even a previously soldered seam, the wire may become attached to your work, so it's best not to let the wire cross a seam. If this situation can't be avoided, solder that seam first and then raise the wire above the previously soldered seam by placing pieces of scrap metal on either side, thus bridging the joint. A thin coat of yellow ochre paste painted on the solder seam where the binding wire will cross it will also keep solder from adhering to the wire.

Choose a gauge of binding wire that will bend easily, yet is not so thin that the torch will burn through it: 22 to 28 gauges are the most useful in jewelry. Cut off a piece long enough to wrap around the parts to be secured, plus about three inches. Wrap the binding wire around the pieces loosely and twist the ends of the wire closed, but not tightly. Then, using round or chain nose pliers, make an "S" bend in the wire to tighten it just until the pieces are held securely in place. Binding wire that is too tight may cause a delicate part, such as a bezel, to collapse when heated to soldering temperature.

Pins in a soldering coil are probably the most useful holding device (a soldering coil is a coiled strip of heat-resistant sheet material, held in a shallow metal pan). Regular straight pins used for sewing work well, but be sure to use only steel straight pins; some straight pins are nickel-plated brass, and these will melt. There are also larger (longer and heavier gauge) straight pins and T-pins available in most sewing supply stores.

Straight pins can be bent with pliers to any shape and placed in the grooves of the soldering coil to hold almost anything. Be sure to keep the pins away from previously soldered joints or they may become attached. If the pins do become soldered to the piece, remove them completely before you place the piece in the pickle.

Tweezers of various kinds are indispensable for soldering. The regular straight tweezers will let you hold a small part while a larger base is being heated, and then will let you lower the part into position when the soldering temperature is approached. Even easier to use are crosslock tweezers, which require no hand pressure to hold items firmly. In addition to being held in the hand, crosslock tweezers may be propped up on a heat-resistant surface like a charcoal block or fire brick. Crosslock tweezers may also be held in a separate stand, called a **"third hand."** Since steel will conduct heat, although at a much slower rate than silver or copper, I recommend using crosslock tweezers with an insulating grip, to prevent scorching your fingers. And remember not to put steel tweezers into the pickle!

One word of caution: crosslock tweezers with a very strong grip may mar metal when heated to soldering temperatures, but you can relax that grip. First, heat the tips of the tweezers to red-hot and then let them air-cool, which will anneal or soften the steel. Then bend the tips until you adjust the strength of the grip so that it will hold metal firmly without marring it.

Stands that hold two **alligator clips** in adjustable arms can be useful. Just be sure to anneal the clips (heat to red-hot and air-cool) before using them the first time, or they may damage your work.

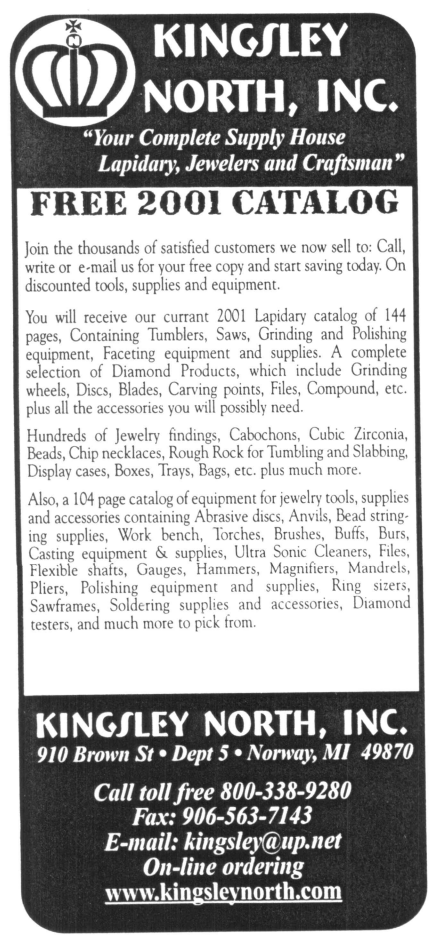
Another handy product for soldering multiple small parts, such as heads for stones, is **soldering investment**. *Caution:* for this procedure, you cannot use regular casting investment or plaster of Paris, which could explode when heated to soldering temperature.

To use soldering investment, place your parts face-up in plasticine (modeling clay) or soft wax, positioned exactly as you want them, and build up a small rim of clay or wax around the parts. This works especially well for soldering many tiny heads together, as it keeps them perfectly aligned: you can shape the clay or wax to duplicate the curve of a ring, for instance.

With your pieces in place, next mix the soldering investment and pour it over the parts. When the investment hardens, in about an hour, carefully peel the wax or clay away, leaving the backs of the parts exposed. After cleaning thoroughly (both wax and plasticine are oil based) with a steam cleaner or solvent, use the torch to heat the investment all around the parts to make sure it is completely dry. Then flux and solder as usual. After soldering is finished, break away the investment, pickle, and clean.

There are a number of other products that can be used to hold parts in place while soldering. **Pumice lumps** or **Carborundum grains** in a small pan will permit you to "nest" odd-shaped parts that need to be joined. A non-asbestos powder mixed with water (such as "Extra Hands") can be **molded like putty** and used to support small parts while soldering. Odd bits of **charcoal block** or **fire brick** can also be shaped to help support parts. Any of these need to be used with some caution: some will scratch metal, while others may either reflect heat or draw it away from the items to be joined.

Whichever soldering aids you choose to use, be sure you understand their limitations! ◆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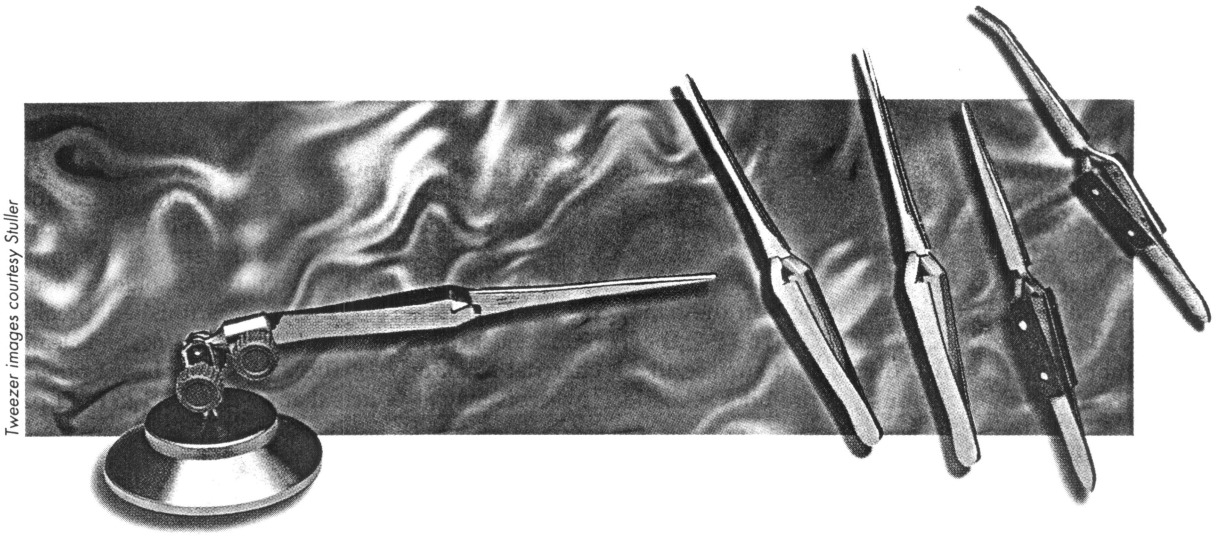


Tweezer images courtesy Stuller

Basic Soldering Tools

Bases, tweezers, and pokers

The metalsmith has many choices in the tools and techniques used in soldering, but certain basic types of tools are essential. These include bases to support the work, tweezers to transport the pieces, and some kind of poker to nudge them into position.

BASES. The optimum situation for soldering silver or gold would be to suspend the items in midair so that the heat could flow freely all around them. But until the law of gravity is repealed, we will need some kind of heat-resistant base to support the parts being joined.

One of the essential setups, which will almost suspend metal in midair, is **a mesh screen on top of a steel tripod**. Use this when it is necessary to heat a piece from underneath, as in sweat soldering. The screen should not be of too fine a mesh, or made of small-gauge wire, because it is easy to burn a hole right through it, even if it is steel. Use a fairly coarse, open-mesh screen for best results.

One word of caution: the tripod is easily tipped over if knocked by the torch or a poker. Drill holes for the legs (at a slight angle) in a piece of scrap wood to give it more stability. This can even be C-clamped to your bench. Also, you can use binding wire to attach the screen to the base, which will prevent it from being knocked off.

Asbestos used to be a popular heat-resistant material for soldering bases, and such materials as millboard and transite board were once standards for supporting hot items. Since the 1980s, however, the manufacture of asbestos products has been banned, but a number of substitutes are now available.

Soldering pads sold under a number of trade names, such as Solderite or Nu-Board, meet OSHA (Occupational Safety and Health Administration) standards. Other flat pads or blocks available are made of silica, garnet, cordierite, magnesia, and various ceramic materials. All are good for silver or gold soldering, and the magnesia is recommended for platinum work, since it will withstand the very high heat needed to solder platinum. Adding a small 3" to 4" lazy-susan base under the pad will make it more versatile.

One of the most useful tools on the soldering bench is the **soldering coil**. A coil of non-asbestos sheeting in a metal pan, this is excellent for helping to keep small parts in place: you can position them on the coil, then stick pins into the coil to wedge the parts into position. When one side of the coil gets too messy to use, simply take it out of the pan and reverse it for a brand-new surface. Be sure to use steel pins, not brass, as brass will melt.

Another traditional base is the **charcoal block**. This reflects heat, and helps to reduce oxides while soldering. It is also easily carved to support odd shapes, or to melt small amounts of metal. Unfortunately, it is fragile and rather expensive. One way to prolong the life of a charcoal block is to wrap thin (about 28 gauge) binding wire several times around the short sides, so that it will hold together even if it breaks. Some jewelers use masking tape, but this will burn.

Fire brick, such as ceramic kilns are made from, is a popular choice for a soldering base. Soft enough to accept pins for holding items and easily carved, fire brick is also lightweight and inexpensive. However, it will scratch soft metals dragged across its surface, unlike a charcoal block or the soldering pads previously mentioned.

If you work a lot with rings, you might find a heat-resistant tapered **ring stick** handy. These are manufactured in both carbon and ceramic materials, and often come attached to their own stands, with replacement rods available.

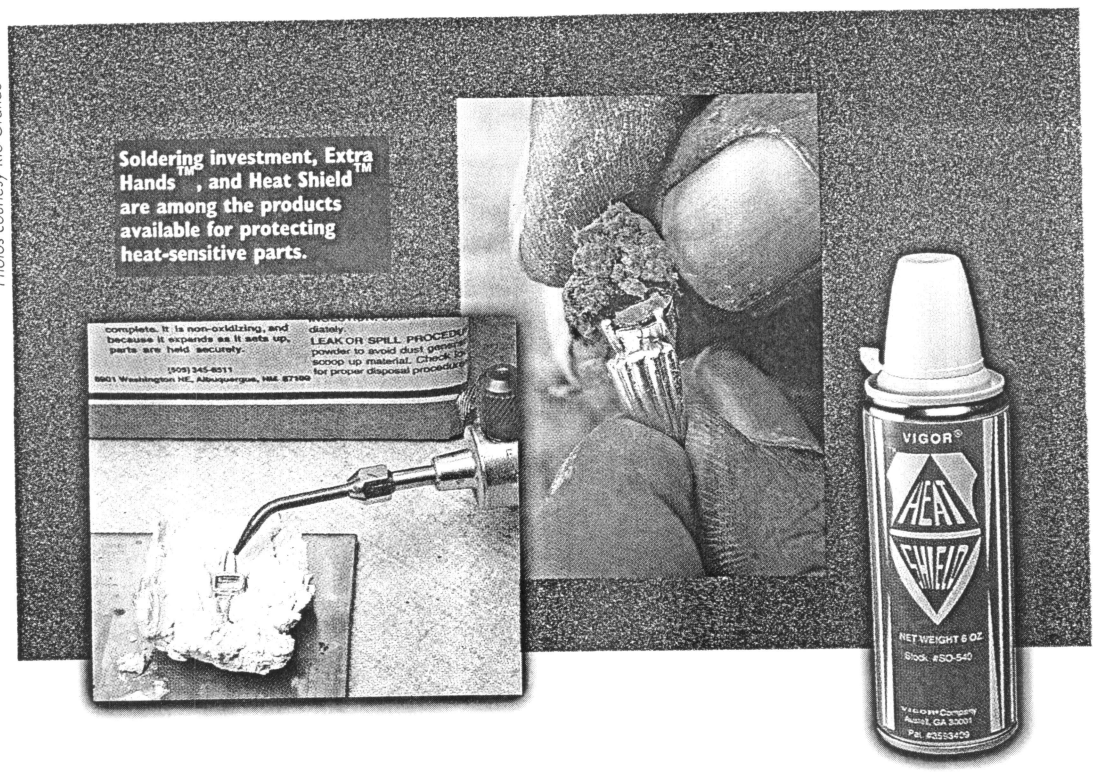
Revolving **annealing pans**, filled with lumps of pumice, charcoal, or Carborundum grains, are used primarily for annealing large work, such as hollowware. But don't forget that both pumice and Carborundum will scratch metal; in fact, both are used as abrasives.

If your studio has a separate soldering area, you can line it with **ceramic tiles** to protect the table or bench surface, usually wood, from the heat of the torch. The tiles that are used underneath a wood stove would be a good choice for this purpose, but any heavy, fired clay tile

Continued on page 18W

Drawing Heat Away

Heat sinks and antiflux.


Soldering investment, Extra Hands™, and Heat Shield™ are among the products available for protecting heat-sensitive parts.
VIGOR
HEAT SHIELD
NET WEIGHT 6 OZ

Photos courtesy Rio Grande

Although much of soldering is about drawing heat toward the intended join, it is also important to keep heat away from certain areas, such as a previously soldered joint, a delicate part like filigree, or a gemstone. A **heat sink** is used to prevent overheating by drawing the heat away from a protected area. Several commercial products are available from jewelry supply stores under trade names such as Kool Jool™, Flame Guard™, Heat Shield™, Extra Hands™, or Cool It™. These are moist, puttylike materials that can be padded around the area that needs protection. Your local welding supply will have similar products,. such as Heat Fence™.

Another solution is to suspend the heat-sensitive area in water while soldering, which could work when you're sizing the back of a ring band. In other instances, if you're soldering on one end of a wire, perhaps onto a forged neckpiece, for example, you could attach several crosslock tweezers just beyond the joint. These would draw the heat away from the forged area, leaving it unannealed; otherwise, you would have to rework it to restore the required stiffness for the neckpiece.

Caution: no heat sink is infallible, so if there is any doubt about how heat-sensitive something is and you can't afford to replace it, find another solution! *Any heat-sensitive stone, such as opal, turquoise, or pearl, or any stone that has likely been treated, such as emerald, should always be removed before soldering.*

Heat sinks are mostly used on silver, which conducts heat rapidly, rather than on gold, which does not. But even on gold, a heat sink will not provide adequate protection in certain situations. Inlay is one of these. When sizing a ring with heat-sensitive inlay materials such as coral, turquoise, or mother-of-pearl, be prepared to replace the inlay completely if you try to solder without removing it. At the very least, whatever glue is used to hold the inlay, such as epoxy, will probably be loosened by the heat.

Sometimes you don't need to prevent the flow of heat but only to keep the solder in a previously soldered joint from melting again. This is the time to use an **antiflux.** Unlike the heat sink, the antiflux does not prevent the heat from traveling through

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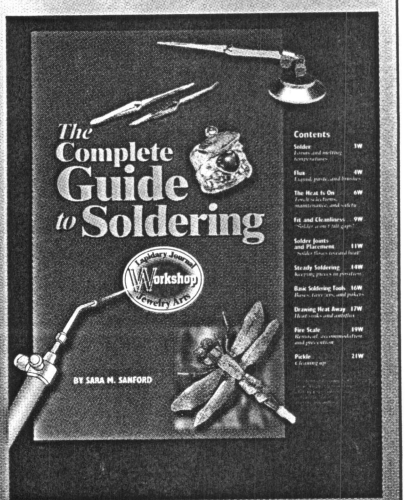

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the metal, but instead takes away one of the five basics of soldering: cleanliness. In other words, it "dirties" the joint so the solder *won't* flow. Antiflux is also useful in preventing solder from flowing into an area where it is not wanted, like the moving parts of a pin catch, or to protect a logo or quality stamp from being filled with solder.

The traditional antiflux is a thin paste of yellow ochre and water. Alternatives are powdered red rouge mixed with alcohol (red rouge is not water soluble) or typewriter correction fluids (such as Wite-out® or Liquid Paper®) sold in office supply stores to cover typing mistakes. These thin solutions are painted on the joints or parts to be protected and then dried thoroughly. The Murphy's Law of antiflux is that if not dried, it will spit out a blob of yellow ochre right into the joint you are trying to solder. If this happens, you will have to clean everything thoroughly and start again. Be especially careful not to let the antiflux and flux mix, since the flux will just draw the antiflux into the joint.

All these antiflux solutions turn dark when heated to soldering temperature and all can be placed in the pickle. However, the yellow ochre and water solution is the easiest to clean up after soldering; also, the correction fluids may give off toxic fumes when heated, depending on the formula.

Caution: antiflux is *not* a heat sink and will not prevent heat from flowing to the protected area. If the area is overheated, the solder may melt and the joint separate anyway, especially if too much stress is placed on the parts. In a complicated situation, you must provide the same support you used during the initial soldering. And never forget that given the chance, gravity will always exert its pull. ◆

Basic Soldering Tools . . .
(continued from 16W)

should work well. However, it's best not to solder directly on these tiles, since concentrating heat in one small spot may cause the tile to crack. Instead, use one or more of the soldering pads on top of the tile.

TWEEZERS. A variety of tweezers is indispensable at the soldering bench. Small pointed tweezers are needed to transport small parts and pallions of solder. Tweezers should not, however, be exposed to the torch flame if possible, and they should be kept clean so they won't contaminate the metal to be soldered or the solder itself.

Crosslock tweezers, which stay closed without pressure, are very handy, both pointed and blunt. Although a bit more expensive, the crosslock tweezers with fiber handles are more comfortable to use when hot. These tweezers come both straight and curved. All are useful for various holding jobs.

There are even a couple of specialty tweezers, made for specific jobs. There are **ring holding tweezers** for soldering wedding and engagement shanks together, and a **head-and-shank tweezer** specially made for holding a solitaire head and shank together while soldering.

POKERS. Since you can't move hot metal parts with your finger, some sort of extension is necessary: a poker to maneuver small parts while soldering. One cheap source is a 4" length of **wire coat hanger** inserted into a ¼" to ⅜" diameter **wooden dowel**. The end can be sharpened to a point and renewed as necessary. Another good (and cheap) source could be your dentist: old **dental tools** can be easily modified into pokers. For very fine pokers, **biology probes** work well.

These probes are all made of steel, however, and solder will stick to steel. The solution is **titanium**, one of the new reactive metals, because solder will not stick to it. Jewelry supply houses sell these pokers, or **pics**, set in either wood or aluminum handles. Titanium has a very high melting temperature and does not conduct heat well, so it will not draw heat away from the joint.

Titanium does have one disadvantage, though: at high heat it will bend very easily, and so is not useful when some pressure needs to be applied. In this situation, a stout steel poker made from a dental tool is the better choice. ◆

Fire Scale

Removal, accommodation, and prevention

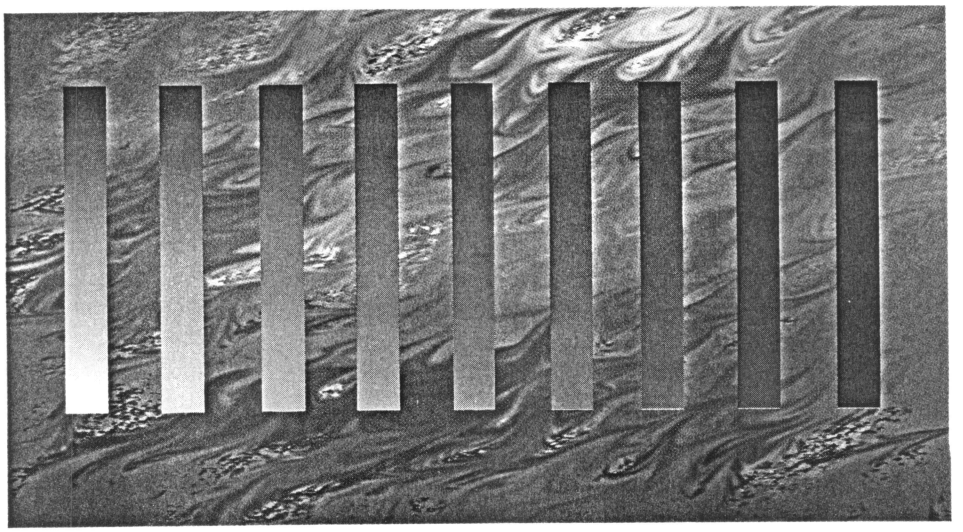


Illustration by Kevin Myers

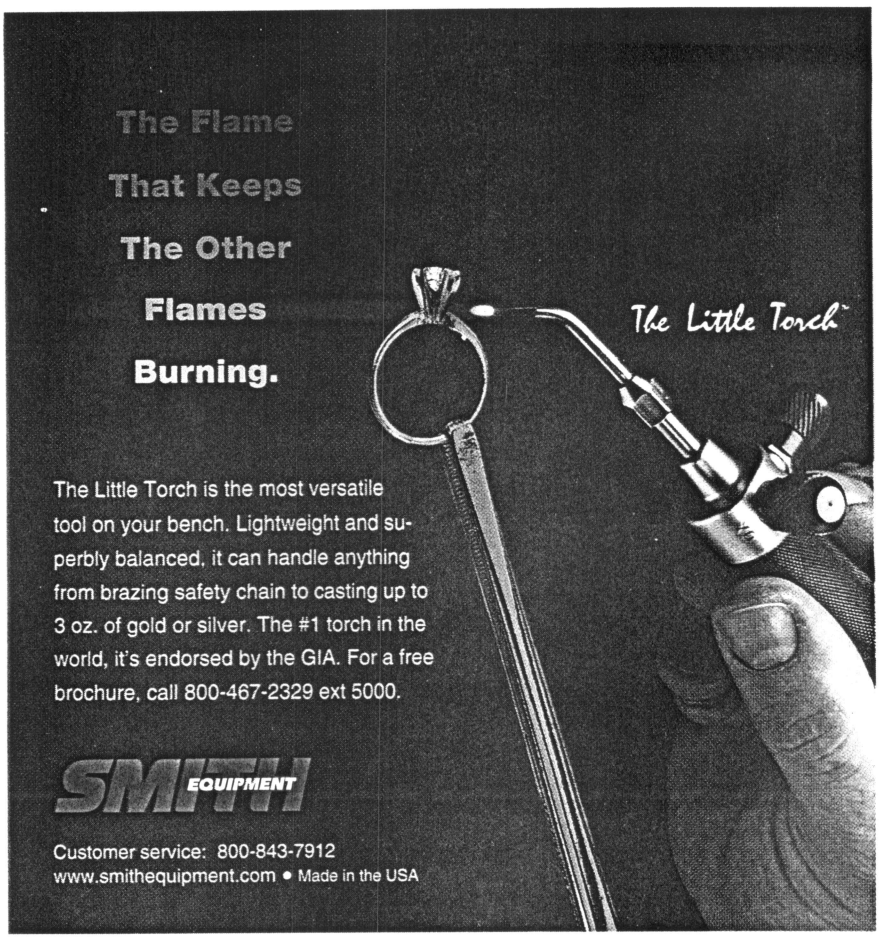
Fire scale is the gray shadow that shows up in ugly blotches as you're putting the final polish on a piece of jewelry. Although you only notice it at the end, fire scale actually forms earlier on, during soldering. This is because when you heat your piece to soldering temperatures — about 1,000°F or above — the oxygen in the ambient air has a nasty habit of combining with the copper in the alloys of sterling silver or the lower-karat golds to form cuprous oxide, a.k.a. fire scale. The blotches are rather easily dealt with on gold — simply by polishing them off — but fire scale can become a real problem for those of us who work in silver.

Once it occurs, there are basically three ways to deal with fire scale: leave it alone (considered unacceptable by most jewelers); remove it completely; or, as some Scandinavians prefer, go to great lengths to put an even coat of fire scale on the whole piece, which will give a dull gray appearance to the metal. On very simple projects, where you'll have easy access to all surfaces with polishing tools, it might be simplest to deal with fire scale in one of these ways. Often, however, it's very difficult to reach every surface after construction; fortunately for cases like these, there are also ways of preventing fire scale from forming in the first place.

Removing fire scale completely means going back to an abrasive polish, either with abrasive paper, abrasive wheels on the flex-shaft, a fairly coarse polish, such as tripoli, or sometimes a quick acid dip. The choice will depend on just how extensive the fire scale is. An acid dip is the quickest but also the most hazardous method. Dealing with acid is always risky for a person; in addition, the acid will remove metal all over the piece, not just where the fire scale is located. By the way, although pickle (Sparex™) is a mild acid, it will not remove fire scale. Instead, it actually covers up the fire scale by depositing a thin layer of fine silver on the surface of the metal.

Accommodating fire scale, or making the most out of it by putting an even coat over the whole piece, uses this characteristic of pickle. By heating and pickling the metal several times, with a slight brass brushing in between, you can build up a very even layer of fire scale. Usually the final finish is not a high polish but a matte or brushed finish, resulting in a darker, more gray color than the bright white of silver without fire scale.

All fire scale **preventatives** work in the same way: to block the oxygen in the air from combining with the copper in the silver alloy. (If we could solder in a vacuum, there would be no fire scale — but of course, there would be no flame, either!) A thin, hard glaze formed on the surface of the metal creates just this sort of barrier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between the oxygen and the copper.

The traditional fire scale preventative compound is a saturated solution of granular boric acid in denatured alcohol. To use it, heat the metal slightly and dip it into the boric acid solution, then flame off the alcohol; repeat this three times, then proceed with soldering. (Boric acid doesn't interfere with the soldering; in fact, it's a compound in some of the fluxes used for soldering.) Several commercial products are available, under trade names such as Cupronil™ or Stop-Ox™. Paste flux, containing borax, is also useful as a fire scale preventative, but it doesn't have the covering power of a boric acid compound.

After soldering is complete and you place your piece in the pickle, it will take a bit longer to dissolve the glaze left by the fire scale preventative than it takes just to clean off other residue. You can help speed up the process by making the pickle solution very warm.

Caution: neither antifluxes nor heat sinks are fire scale preventatives. You must make a choice on which technique will be best for your particular soldering situation, since you cannot use both an antiflux *and* a fire scale preventative in the same place (mixing the two solutions allows them to react and renders both useless). They can, however, be used in different areas on the same piece. Theoretically, using a heat sink prevents the area from getting to the temperature where fire scale forms, but again, this is not infallible.

Fire scale requires time and effort no matter how you approach it: initially in preventing it, later in removing it, or by creating an even coating as a finish. The choice is simply in where and when you put the time and effort. ◆

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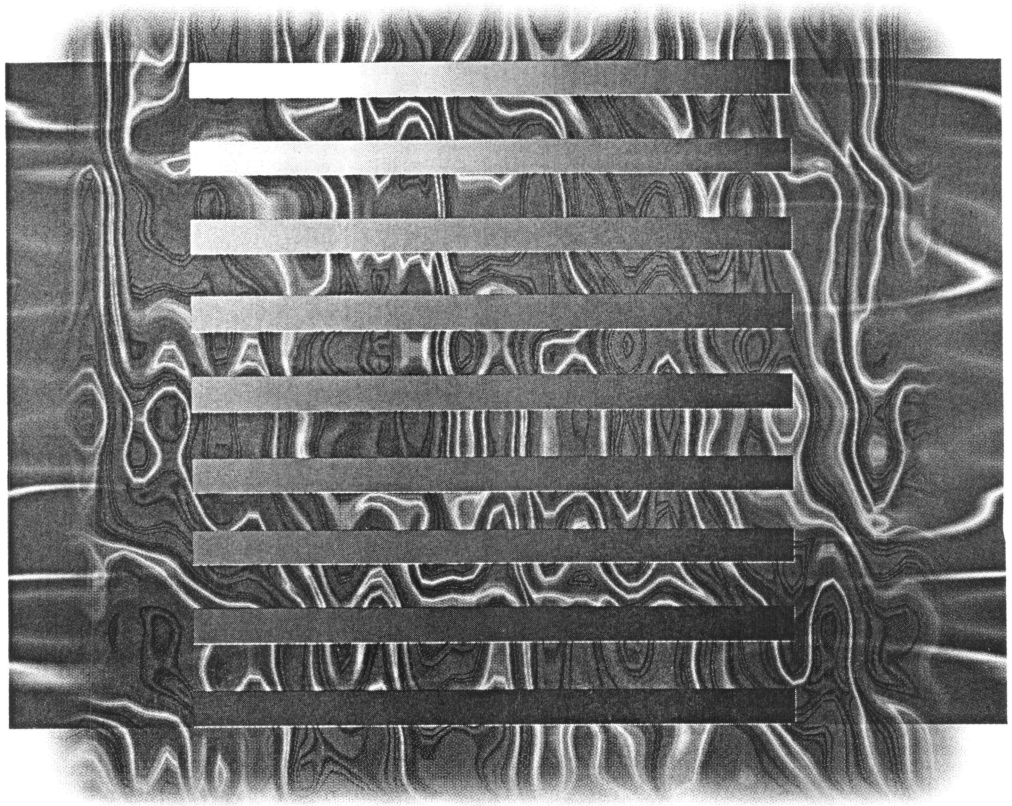
Pickle

Cleaning up after soldering



When you heat up your work for soldering and reach the temperature at which solder flows, you are also creating oxides on the surface of your metal that mar its appearance. In November, we dealt with removing a particularly tricky oxide called fire scale. Other surface oxides are easier to remove, and for these the jeweler can use an acid solution commonly called pickle, which will also remove the residue of flux at the same time. You can also remove these oxides by abrasion using files or abrasive paper, but using a pickle is more efficient.

The traditional pickle used to be a 5% to 10% solution of sulfuric acid, but because both the fumes and any splashes are hazardous to humans and anything else around, many jewelers now use a commercially prepared, dry, granular, sodium bisulfate compound, which is a safer substitute but should still be used with care. Probably the best-known is Sparex #2™, though various supply companies also have their own house brands. There are also special compounds for nickel or German silver, and even a Sparex #1™ for iron or steel.

Another pickle compound that has recently been touted is citric acid. You can find this "anhydrous fine granular citric acid" in the canning section of grocery stores, or you can purchase larger quantities from commercial chemical companies. While this seems to be even less toxic than Sparex™, its disadvantages are that it must be used while quite hot, creating the potential for burns, and it works more slowly than Sparex™. Jewelers all over the country are still trying out citric acid, and final results are not yet available. Some swear by it, especially for its non-toxic aspect, but others have returned to using Sparex™.

How strong to make your pickle solution is a matter of personal choice. I usually start with about a quarter cup of Sparex™ in one pint of water. If your solution seems too strong or leaves etch marks on your metal, you can dilute the solution with water. As the pickle is used, it absorbs copper ions that reduce its ability to clean metal. You can tell when pickle is about at the end of its usefulness when its color turns dark blue-green from the absorbed copper. At that

Illustration by Kevin Myers

point, you can add more Sparex™.

All pickling solutions work best when heated to about 180°F. What's the best way to warm them up? A number of commercial electric pickle pots are available that are designed specifically to keep the solution warm, but a crock pot also works well and is much less expensive. The home appliance manufacturer Rival makes a one-quart crock pot called a Crockette™, which is ideal for most jewelry use. Since the fumes from a pickling solution are corrosive, I have long failed to understand why the commercial pickle pots don't have covers; all the cheaper home crock pots do come with covers, making them an even better choice. Of course, once you've used your crock pot for pickle, you should never use it for food preparation.

Other choices for a pickle pot, used on a gas or electric burner, include the traditional copper pan; a Pyrex™ or Corning™ ware dish, enamel ware, or a stainless steel pan. Do not use regular steel or iron containers for pickling since the ferrous metals will cause a catalytic reaction that will then copper-plate anything put into the container. For this same reason, you should always remove all steel pins or binding wire before placing pieces in the pickle; likewise, you should never use steel tongs or tweezers when removing items from the pickle. And any pickle container should be covered, both for safety and to prevent evaporation.

Copper tongs are the standard tool for retrieving items from the pickle; you can also use bamboo, wood, or plastic tongs or tweezers. There are also tweezers with plastic-coated tips, but you need to be careful not to submerge the non-coated part in the pickle. I keep a small Pyrex™ bowl filled with fresh water right next to my pickle pot and automatically dunk the item into the water when I take it out of the pickle. Some people use a solution of baking soda and water to help neutralize the acid, but this really isn't necessary unless you're using sulfuric acid or an exceptionally strong solution of Sparex™. But it is necessary to wash all traces of pickle off the piece before continuing to work on it.

Small parts such as findings or settings can easily get lost in the pickle pot, so a small container is handy to have when pickling such tiny items. A miniature plastic jar, drilled all over with minute (less than .040" or 1mm) holes works well. Plastic caps from liquid laundry detergent bottles or paint spray cans or anything that's about this size (2" in diameter and 1½" tall) are easily accessible and free. Attach a copper wire handle to the cap or whatever you're using, making it stand high enough so that it extends out of the pickle solution, and your small-parts basket is ready for use.

Removing a flat sheet from the pickle pot can also be a challenge. In fact, it's almost impossible to grab a sheet with tongs or tweezers if it's lying flat on the bottom of the pot. The best way to deal with this situation is to avoid it, which you can do by creating an uneven surface on the bottom of the pot, for example, by placing in it a small lump of metal, glass, plastic, or other material not affected by the pickle. This will leave the metal sheet slightly raised, giving you a spot to grasp with the tongs or tweezers.

Over time, the pickle solution becomes contaminated with metal oxides, flux, antifluxes such as yellow ochre, bits of heat-sink material, casting investment, and other stuff. You can easily clean all this particulate matter out of the pickle by pouring it through a paper coffee filter. For safety, do this while the pickle solution is cold, and do it in a sink in case of spills.

While it is never advisable just to throw very hot items into the pickle, some splashing is inevitable: dropping hot metal into liquid makes it hiss and spit. First, you should let things cool off a bit to minimize splashing, and then when you do put your items in, use the lid as a shield, held just above the pickle pot. You should also protect the area around the pickle pot with either an acid-proof material or one that is easily and cheaply replaced. And since this will be in the soldering area, you also want this shield to be nonflammable.

A simple three-fold screen of aluminum foil is one possibility. Make three brass rod or wood dowel frames about 9" wide by 12" high. Join them with binding wire so they will stand up but remain flexible, and cover them with heavy-duty aluminum foil, leaving a slot near the bottom of one panel through which you can fit the plug of the pickle pot. Don't forget to protect the area under the pickle pot as well. ◆

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